

## WIRELESS COMMUNICATION APPARATUS AND SYSTEM

5 Field of the Invention:

10 wireless control apparatus.

15 connected to the wireless control apparatus.

15 connected to the wireless control apparatus.

20 communication channel used in this communication between  
the master and slave and so notifies the slave using a  
control channel, whereupon the slave is shifted to the  
communication channel of which it has been notified,  
thereby establishing a wireless link.

25           When communication ends, control for the purpose of  
cutting off the wireless link is carried out over a

prescribed period of time, whereupon the wireless link is cut.

However, when an incoming call to the slave is detected after communication ends, the wireless link is cut temporarily. This is despite the fact that the wireless link has not been cut through the link cutting control operation because this operation is still in progress. This means that a new control channel is temporarily occupied to search for and decide upon an idle communication channel and establish a wireless link anew, whereupon communication commences. This procedure takes time. Moreover, if the wireless link cannot be established the second time, it may not be possible to perform communication in response to the incoming call.

Further, in order to make all slaves ring at the time of an incoming call from a communication line in a situation where a plurality of slaves exist, wireless links are established to all of the slaves. If an outgoing call is then abandoned by disconnection on the calling side, the wireless links to the slaves are cut. Or, if a slave responds to the incoming call, the wireless links to slaves other than the responding slave are disconnected.

Accordingly, if a party not sought by the calling side answers the incoming call, it is required that the call be transferred. When the transfer is made, the

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slave that is the destination of the transfer must re-establish the wireless link and the calling party is made to wait until this is achieved.

In particular, when there is an incoming call from another outside line or an outgoing call to a communication apparatus of another extension in the case of communication apparatus or private branch exchange accommodating a plurality of communication lines (outside lines) and also having a number of extensions, there are instances where a procedure for establishing a wireless link with the other communication apparatus is made to wait while a procedure for establishing a wireless link is being executed for the incoming call or outgoing call. It may take several seconds or more before the communication apparatus that is the destination of the transfer answers or before there is a hold response made by the other communication apparatus. The result is poor operability.

#### SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to eliminate the troublesome task of re-establishing a wireless link and use an already established wireless link as is in a case where an incoming call arrives at a wireless communication terminal after the end of communication, thereby making it possible to start communication rapidly without occupying a control

channel for a fixed period of time for the purpose of establishing the wireless link.

Another object of the present invention is to maintain a wireless link for a period of time longer  
5 than that required to disconnect the wireless link after communication ends.

A further object of the present invention is to provide a wireless communication system in which, in an instance where a calling party receives a response from  
10 a party different from the intended party after the incoming call from a public telephone line is terminated and answered, as is often the case where a hold-and-transfer operation is used most frequently, the operation for effecting transfer to another  
15 communication terminal or for holding and answering at another communication terminal is facilitated.

Still another object of the present invention is to make it possible to adjust the time needed to disconnect a wireless link after communication ends.

20 Still another object of the present invention is to make it possible to adjust the time needed to disconnect the wireless link of a communication terminal other than a communication terminal that has responded to an incoming call, the purpose being to achieve a speedy  
25 transfer to the other communication terminal after an incoming call from a telephone line to a plurality of

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wireless communication terminals is terminated and answered or to achieve a prompt holding response at the other communication terminal.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

10                   BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the construction of a wireless telephone system according to a first embodiment of the present invention;

Fig. 2 is a sequence chart showing an example of operation of the wireless telephone system according to the first embodiment;

Fig. 3 is a flowchart showing an example of the operation of a main unit according to the first embodiment;

20           Fig. 4 is a flowchart showing an example of the operation of a slave according to the first embodiment;

Fig. 5 is a block diagram illustrating the construction of a wireless telephone system according to a second embodiment of the present invention;

25           Fig. 6 is a sequence chart showing an example of operation of the wireless telephone system according to

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Fig. 7 is a block diagram illustrating the construction of a wireless telephone system according to a third embodiment of the present invention;

Fig. 9 is a flowchart showing an example of the operation of a communication control apparatus according to the third embodiment;

Fig. 11 is a block diagram showing a cordless key telephone system according to a fourth embodiment of the present invention;

20            Fig. 13 is a flowchart showing an operation in  
which a main unit stores the status that prevails when a  
wireless link is connected in the fourth embodiment;

Fig. 15 is a sequence chart showing operation up to

Fig. 16 is a sequence chart showing operation when a hold response is made from a state in which a wireless link is disconnected in the fourth embodiment;

Fig. 18 is a flowchart showing operation of a dedicated extension cordless telephone at the time of a made in the fourth embodiment;

Fig. 20 is a block diagram illustrating the construction of a system according to a sixth embodiment of the present invention;

Fig. 22 is a block diagram showing the construction of a main unit according to a seventh embodiment of the invention; and

of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the  
5 drawings.

Fig. 1 is a block diagram showing a wireless telephone system according to a first embodiment of the present invention.

This system comprises a cordless slave (referred to  
10 as a "slave" below) 1, i.e., a wireless slave, and a key telephone master (referred to as a "main unit" below) 2.

The slave 1 has a memory 110 for processing and stores a call end-processor 111, an incoming-call processor 112 and a call processor 113, an operational  
15 controller 120 for supervising control of the slave, a wireless unit 130 for supervising wireless connection and disconnection between the slave and the main unit 2, a lamp display 140 which flashes a main-wire lamp for an incoming call to an outside line; an LCD display 150 for  
20 displaying the telephone number of an incoming call to an outside line, and a transmitter/receiver 160 for transmitting and receiving (talking and listening).

The main unit 2 has a memory 210 which stores a terminating/transmitting processor 211, a call-end  
25 processor 212 and a call processor 213, an operational controller 220 for supervising control of the main unit,



a wireless unit 230 for supervising wireless connection and disconnection between the main unit 2 and a slave, a communication-line controller 240 for managing or controlling a main wire such as a public telephone line, and a wireless-link disconnect timer 250. The timer 250 may be implemented by executing program processing within the operational controller 220.

Fig. 2 is a sequence chart showing an example of operation of the wireless telephone system according to the first embodiment, and Fig. 3 is a flowchart showing an example of the operation of the main unit 2 according to the first embodiment.

As shown at step 301 in Fig. 3, the operational controller 220 starts up the call processor 213 within the memory 210 to execute call processing. If, during this processing, notification that slave 1a is on the hook is received via the wireless unit 230 at step 303 without detection of an incoming call to the slave 1a at step 302, the operational controller 220 starts up the call-end processor 212 in memory 210 at step 304 and transmits a standby-state transition request, which is for placing the master on standby while maintaining the established wireless link, to the slave 1 at step 305 via the wireless unit 230 under the command of the operational controller 220. At this time the main unit 2 determines at step 306 whether or not there is an

incoming call to the slave 1a. If there is no incoming call, the wireless-link disconnect timer 250, which is for disconnecting the wireless link upon elapse of a prescribed period of time, is started at step 307 in response to a command from the operational controller 220. If there is an incoming call ("YES" at step 309) to the slave 1a before the timer runs out of time ("NO" at step 308), the operational controller 220 resets the wireless-link disconnect timer 250, starts the terminating/transmitting processor 211 in the memory 210 and, in order to notify the slave 1a of the incoming call, sends an outside-line terminate request to the slave 1a at step 310 using the wireless link already established by the preceding call via the wireless unit 230. Then, if notification of the fact that the slave 1a has been taken off the hook is received from the slave 1a at step 311 by the wireless link that was being used by the preceding call, the operational controller 220 starts the call processor 213 in the memory 210 and executes processing (step 312) for calling the slave 1a using the wireless link already established by the preceding call via the wireless unit 230.

If an incoming call to the slave 1a is detected at step 306 when notification of the end of the call has been received from the slave 1a, the operational controller 220 starts the terminating/transmitting

processor 211 in the memory 210 and sends the outside-line terminate request to the slave 1a via the wireless unit 230 at step 310 using the wireless link already established by the preceding call. Thereafter, if  
5 notification of the fact that the slave 1a is off the hook is received from the slave 1a at step 311, the operational controller 220 starts the call processor 213 in the memory 210 to execute call processing (step 312) with respect to the slave 1a.

10 If the fact that the timer 250 has run out of time is detected by the operational controller 220 at step 308, then, in order to disconnect the wireless link, the operational controller 220 sends a wireless-link disconnect request to the slave 1a via the wireless link  
15 230 at step 313 and disconnects the wireless link at step 315 when confirmation of wireless-line disconnection from the slave 1a is received via the wireless unit 230 at step 314.

If an incoming call is detected (as by a telephone  
20 beeper service) at step 302 during communication, the operational controller 220 sends the slave 1a, via the wireless unit 230, the outside-line terminate request to inform the slave 1a of the incoming call (step 316). If notification that slave 1a is off the hook is received  
25 from the slave 1a (step 317), then the operational controller 220 sends notification of this fact to the

exchange via the public telephone line (step 318). The exchange places the call on hold and transmits a call signal with regard to the terminating call. As a result, the operational controller 220 executes call  
5 processing (step 319) with respect to the slave 1a using the established wireless link as is. When notification of the fact that the slave 1a is on the hook is received again (step 320), the operational controller 220 communicates this fact to the exchange (step 321) so  
10 that the call that was in the held state is started again.

Fig. 4 is a flowchart showing operation of the slave 1a according to this embodiment.

In Fig. 4, the operational controller 120 starts  
15 the call processor 113 in memory 110 and executes call processing at step 401 using the transmitter/receiver 160 and wireless unit 130. If the handset of the transmitter/receiver 160 is on the hook ("YES" at step 402), the operational controller 120 so notifies the  
20 main unit 2 (step 403) via the wireless unit 130. If beeper service is being received, the call processing in response to the incoming call is continued (step 404) using the established wireless link. If beeper service is not being received, however, the operational  
25 controller 120 of the slave 1a that has received a standby-state transition request (step 405) from the

main unit 2 via the wireless unit 130 starts the call-  
end processor 111 in memory 110 at step 406 and causes  
the LDC display unit 150 to present a display indicative  
of the standby state at step 407. The operational  
5 controller 120 then undergoes a transition to the  
standby state.

The wireless link that was being used in the  
preceding call is kept as is until the wireless-link  
disconnect request is received from the main unit 2.

10 Upon receiving notification of outside line  
termination from the main unit 2 via the wireless unit  
130 at step 408, the operational controller 120 starts  
the incoming-call processor 112 in memory 110 at step  
409 and causes the LDC display unit 150 and lamp display  
15 unit 140 to display the fact that the incoming line has  
arrived at the outside line (step 410).

When the operator observes the LDC display unit 150  
and lamp display unit 140 and takes the phone off the  
hook at step 411, the operational controller 120  
20 transmits notification of this fact to the main unit 2  
(step 412) using the wireless link that was being used  
in the preceding call and then starts the call processor  
113 in memory 110 to execute call processing with regard  
to the above-mentioned outside line (step 413).

25 If notification of the incoming call to the outside  
line is not received from the main unit 2 at step 408

and the wireless-link disconnect request is received from the wireless unit 130 at step 414, the operational controller 120 transmits a wireless-link disconnect confirmation signal to the main unit 2 via the wireless unit 130 at step 415 to disconnect the wireless link at step 416.

Fig. 5 is a block diagram based upon a wireless system according to a second embodiment of the invention.

The system of Fig. 5 differs from that of Fig. 1 in that a cordless master (referred to as a "master" below) 3 serving as a wireless master is connected to the main unit 2 by a wire line 2, with the master 3 being provided internally with a transfer section 310 for transfer of wireless communication between the main unit 2 and the slave 1. Other components are similar to those of the first embodiment (Fig. 1) and need not be described again.

Fig. 6 is a sequence chart showing an example of operation of the wireless telephone system according to this embodiment.

The master 3 relays wireless communication between the main unit 2 and slave 1 by using the transfer section 310, thereby effecting a transfer operation. The operation of the main unit 2 and each of slaves 1a ~ 1N is the same as in the first embodiment and need not

be described again.

If the cord length between the main unit 2 and master 3 is extended by adopting an arrangement of the kind shown in Fig. 5, the slaves 1 can be deployed over  
5 a wider area.

Fig. 7 is a block diagram illustrating a third embodiment of the present invention.

In this embodiment, as shown in Fig. 7, the wireless unit in the main unit 2 is eliminated, and the  
10 master 3 is provided with a memory 310 storing a terminating/transmitting processor 311, an operational controller 320 for supervising control of the master 3, a wireless unit 300 for performing wireless connection and disconnection between the master 3 and a slaves 1,  
15 and a timer 340. Other components are similar to those of the second embodiment shown in Fig. 5.

Thus, the third embodiment is characterized by the fact that the sections for processing relating to connection of the wireless link are provided in the  
20 master 3 to execute this processing.

Fig. 8 is a sequence chart showing an example of operation of the wireless system according to the embodiment of the invention.

Fig. 9 is a flowchart showing an example of the  
25 operation of the communication control apparatus 2 according to this embodiment.

As shown at step 901 in Fig. 9, the operational controller 220 executes call processing with respect to the slaves 1. If, during this processing, notification that slave 1a is on the hook is received via the master 3 at step 903 without detection of an incoming call to the slave 1a at step 902, the operational controller 220 starts up the call-end processor 212 in memory 210 at step 904 and transmits a standby-state transition request to the master 3 at step 905.

If there is an incoming call to the slave 1a at step 906, the operational controller 220 starts the terminating/transmitting processor 211 in the memory 210 and transmits an outside-line terminate request to the master 3 at step 907. Then, if notification of the fact that the slave 1a has been taken off the hook is received from the master 3 at step 908, the operational controller 220 starts the call processor 213 in the memory 210 and executes processing (step 909) for calling the slave 1a.

If an incoming call to the slave 1a is detected at step 902, the operational controller 220 sends the outside-line terminate request to the master 3 at step 910. If notification of the fact that the slave 1a is on the hook is received from the slave 1a at step 911, the operational controller 220 notifies the exchange of this fact via the public telephone line at step 912 and



executes call processing with respect to the incoming call at step 913.

When notification of the fact that the slave is on the hook is received again (step 914), the operational  
5 controller 220 communicates this fact to the exchange (step 915) and executes call processing for calling the slave 1a.

Fig. 10 is a flowchart showing an example of operation of the master 3 according to this embodiment.

10 Processing (step 1001) for relaying communication between the slave 1a and communication control apparatus 2 is performed by the wireless unit 330 in response to a command from the operational controller 320. If  
15 notification of the fact that the slave 1a is on the hook is received from the slave 1a ("YES" at step 1003) without the outside-line terminate request being sent from the communication control apparatus ("NO" at step 1002), notification of the fact that the slave 1a is on the hook is transferred to the communication control  
20 apparatus 2 (step 1004). If the standby-state transition request is subsequently received from the communication control apparatus at step 1005, the operational controller 320 starts the wireless-link disconnect timer 340 at step 1006 and transmits the  
25 standby-state transition request to the slave 1a via the wireless unit 330 at step 1007. If the outside-line

5 processor 311 in memory 310 at step 1010 and transmits the outside-line terminate request to the slave 1a at step 1011 using the wireless link that was being used in the preceding call.

10 is subsequently received from the slave via the wireless unit 330 ("YES" at step 1012), the operational controller 320 transfers notification of this event to the communication control apparatus 2 (step 1013) and executes processing (step 1001) for the relay operation  
15 between the slave 1a and the communication control apparatus 2.

20 link disconnect request to the slave 1a (step 1014) via  
the wireless unit 330 by the wireless link that was  
being used in the preceding call. If confirmation of  
disconnection of the wireless link is received from the  
slave 1a via the wireless unit 330 by the wireless link  
25 that was being used in the preceding call (step 1015),  
the operational controller 320 disconnects the wireless

link at step 1016.

If the outside-line terminate request is sent from the communication control apparatus during relay processing ("YES" at step 1002), the request is  
5 transmitted to the slave 1a (step 1017). If notification that the slave 1a is on the hook is received from the slave ("YES" at step 1018), notification of this fact is transmitted to the communication control apparatus at step 1019. When  
10 transfer of this notification is finished, processing (step 1020) for relaying the communication between the communication apparatus and the slave 1a is performed using the established wireless link.

When notification that the slave 1a is on the hook  
15 is received ("YES" at step 1021), notification of this fact is transmitted to the communication control apparatus at step 1022 and relay processing is executed again.

The operation of the slave 1a is similar to that of  
20 the first embodiment and need not be described again.

By adopting this embodiment, the processing relating to the wireless link is executed almost entirely within the master 3. As a result, the communication control apparatus 2 can transmit commands  
25 without taking the status of the wireless link into account, and it will suffice to provide the same program

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irrespective of processing of a wired telephone. A particular advantage of this invention is that it is possible to create the program of the communication control apparatus 2 without being aware of the fact that  
5 the telephone is a wireless telephone.

The first, second and third embodiments are described in conjunction with an incoming call to an outside line. However, if the system is one in which a call can be placed to an extension, the same effects can  
10 be obtained by performing a similar operation when the incoming call is to the extension.

Further, the method of wireless control in Figs 1, 5 and 7 may be in accordance with the system ID method or an individual ID method. Though a call is described  
15 as being an outside line call in the first, second and third embodiments, calls may be extension calls, door intercom calls or private branch calls.

Further, though the first, second and third embodiments are described with regard to wireless  
20 telephone calls, the same effects can be obtained by applying the present invention to a wireless communication system in which data communication or the like is performed wirelessly.

Further, if an arrangement is adopted in which the  
25 times to which the timers 250, 340 of the first, second and third embodiments are set can be adjusted by an

external operation, a system conforming to various applications can be provided.

Thus, in accordance with the embodiments of the invention as described above, if an incoming call  
5 arrives at a wireless communication apparatus while the wireless communication apparatus is performing communication or within a prescribed period of time from the end of communication, the wireless link that was established by such communication can be utilized as is,  
10 i.e., without being disconnected. As a result, notification of the incoming call and telephone communication can be carried out smoothly without the task of establishing a wireless link anew for the next communication operation and without taking too much  
15 time.

Fig. 11 is a block diagram showing the construction of a cordless key telephone system according to a fourth embodiment of the present invention.

A key telephone apparatus has a main unit 1102  
20 which includes a switching section for switching voice calls and the like, outside-line controllers 1104a, 1104b, which accommodate a public switched telephone network (PSTN) 1101, for detecting an incoming call from a telephone line and sending a dialed number to a  
25 telephone line, extension wireless controllers 1105a, 1105b for controlling dedicated extension cordless

telephones 1110a, 1110b, respectively, a sound source 1106 for generating a DTMF signal sent to a telephone line, a holding tone and various other tones, a main controller 1107 for controlling the cordless key  
5 telephone apparatus in various ways, a ROM 1108 storing a control program for controlling a timer used in this embodiment as well as the overall main unit 1102, and a RAM 1109 for storing various data.

The dedicated cordless telephones 1110a, 1110b are  
10 connected to the main unit 1102 by wireless links that have been established by a control channel.

Fig. 12 is a block diagram showing the internal construction of the dedicated extension cordless key telephones 1110a, 1110b.

15 As shown in Fig. 12, the dedicated extension cordless key telephone 1110 includes an antenna 1202 for sending and receiving radio waves, a wireless controller 1203 for sending and receiving radio waves to and from the main unit and detecting whether a wireless link with  
20 the main unit has been established, an audio processor 1204 for linking a voice between the main unit and a handset and for sending and receiving control data to and from the main unit, a main controller 1205 for controlling this mobile device in various ways, a ROM  
25 1206 in which a control program and the like are stored, a RAM 1207 for storing various data, an earphone 1208, a

microphone 1209, a control panel 1210 having outside-line buttons, push buttons for dialing and a hold button, etc., a display unit 1211 comprising a liquid-crystal display device or LEDs (light-emitting diodes),  
5 and a speaker 1212 for sending an incoming-call tone.

When the dedicated extension cordless key telephone 1110a is taken off the hook in order to make a transmission to the PSTN 1101, a procedure for establishing a wireless link between the dedicated  
10 extension cordless key telephone 1110a and the extension wireless controller 1105 is executed. After the wireless link is established, off-hook information is transmitted from the dedicated extension cordless key telephone 1110a to the extension wireless controller  
15 1105a.

Upon receiving the off-hook information from the dedicated extension cordless key telephone 1110a, the extension wireless controller 1105a communicates this information to the main controller 1107.

20 Upon receiving the off-hook information, from the dedicated extension cordless key telephone 1110a, sent by the extension wireless controller 1105a, the main controller 1107 causes the outside-line controller 1104a to acquire a telephone line.

25 Thereafter, when a dial button on the dedicated extension cordless key telephone 1110a is pushed, a

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dialing signal is sent to the extension wireless controller 1105a by the established wireless link, the extension wireless controller 1105a communicates the dialing signal to the main controller 1107, and the  
5 latter sends the signal from the outside-line controller 1104a to the telephone line.

When the subscriber's number of the communicating party (not shown) has been dialed in full, the number is terminated at the communicating party and the party  
10 answers, it becomes possible for the communicating party to communicate with the dedicated extension cordless key telephone 1110a via the PSTN 1101 and the outside-line controller 1104a, switching section 1103 and extension wireless controller 1105 in the main unit 1102.

15 When there is an incoming call from a telephone line, the outside-line controller 1104a detects the incoming call and communicates the incoming-call information to the main controller 1107.

Upon being notified of the incoming-call  
20 information, the main controller-1107 establishes a wireless link between the extension wireless controllers 1105a and 1105b and the dedicated extension cordless key telephones 1110a, 1110b in order to produce an incoming-call tone.

25 The extension wireless controllers 1105a and 1105b execute a procedure for establishing a wireless link

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with the dedicated extension cordless key telephones  
1110a and 1110b. When this procedure is completed, the  
extension wireless controllers 1105a and 1105b  
communicate establishment-completed information to the  
5 main controller 1107.

Upon receiving the establishment-completed  
information, the main controller 1107 causes the  
extension wireless controllers 1105a, 1105b to send  
incoming-call information to the dedicated extension  
10 cordless key telephones 1110a, 1110b.

Furthermore, the main controller 1107 transmits the  
incoming-call tone from the sound source 1106 to the  
dedicated extension cordless key telephones 1110a, 1110b  
via the switching section 1103 and extension wireless  
15 controllers 1105a, 1105b so that the incoming-call tone  
is produced by the speaker 1212 of each of the dedicated  
extension cordless key telephones 1110a and 1110b.

When the dedicated extension cordless key telephone  
1110b is taken off the hook in response to the incoming  
20 call, an operation similar to that performed at the time  
of transmission is carried out. Specifically, the off-  
hook information is transmitted, this information is  
communicated from the extension wireless controller  
1105b to the main controller 1107, the main controller  
25 1107 causes the outside-line controller 1104a to acquire  
a telephone line, a response is made to the incoming

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call and communication with the originating party (not shown) can be achieved in the same manner as at the time of transmission.

Next, an operation for storing the status of the  
5 main unit 1102 when a wireless link is established will be described in conjunction with the flowchart of Fig. 13.

In a state in which a wireless link has not been established between the extension wireless controller  
10 1105a and the dedicated extension cordless key telephone 1110a, the main controller 1107 waits for notification of the off-hook information, from the dedicated extension cordless key telephone 1110a, sent by the extension wireless controller 1105a (step S1301). If  
15 the information is not communicated to the main controller 1107, the main controller 1107 waits for notification of incoming-call information, from the telephone line, sent by the outside-line controller 1104a (step S1302). If the incoming-call information is  
20 not received, the program returns to step S1301.

If the off-hook information from the dedicated extension cordless key telephone 1110a has been communicated at step S1301, the fact that a connection has been made by the off-hook operation is stored in the  
25 RAM 1109 as the status at the time the wireless link is established (step S1306). A transition is then made to

the transmission state (step S1307).

If the incoming-call information indicative of the incoming call to the outside line is communicated at step S1302, then the fact that an incoming-call  
5 connection has been made is stored in the RAM 1109 as the status at the time the wireless link is established (step S1303) and the extension wireless controller 1105a is made to execute the procedure for establishing the wireless link (step S1304). A transition is then made  
10 to step S1305, at which completion of wireless-link establishment is awaited.

Thus, status at establishment of the wireless link with a dedicated extension cordless key telephone is stored in the RAM 1109 by the main unit 1102.

15 The operation of main unit 1102 when a wireless link is cut will now be described in conjunction with the flowchart of Fig. 14.

When the extension wireless controller 1105a and the dedicated extension cordless key telephone 1110a are  
20 wirelessly linked, the main controller 1107 monitors the hook status of the dedicated extension cordless key telephone 1110a (step S1401). If the telephone is off the hook, the program returns to step S1401. If the telephone is on the hook, the main controller 1107  
25 monitors the incoming-call status of the outside line (step S1402). If an incoming call is still in progress,

the program returns to step 1401. If there is no incoming call, the main controller 1107 checks a disconnect timer (step 1403). If the timer is not operating, the main controller 1107 checks the status, stored in the RAM 1109, that prevailed when the wireless link was established (step S1404). In case of an off-hook connection, namely disconnection due to placing the telephone on the hook, the main controller 1107 starts a timer T1 (e.g., 5 sec) (step S1405). In case of an incoming-call connection, the main controller 1107 checks whether the incoming call was suspended (step S1406). If the call was abandoned from the originating side in mid-course, the program proceeds to step S1405, where the disconnect timer T1 is started.

If the call from the originating side is not abandoned at step S1406 and the dedicated extension cordless key telephone 1110b responds to the incoming call, the main controller 1107 starts a disconnect timer T2 (e.g., 20 sec), which has been set to a time longer than that of the disconnect timer T1, and the program returns to step S1401.

If the disconnect timer has already been started at step S1403, the timer performs a counting operation (step S1408) and the program returns to step S1401 if the timer has not run out of time. If the timer has run out of time, the timer is halted and a procedure for

cutting the wireless link is started (step S1409), after which the program makes a transition to step S1410 to wait for completion of the wireless-link disconnection.

It should be noted that the timer simply performs a counting operation at step S1408. However, if the timer value is set and time is counted down when the disconnect timer T1 or T2 is started, it is possible to execute processing regardless of whether the timer that has started is T1 or T2.

Thus, it is so arranged that when an operation for responding to an incoming call is detected, the wireless link with the extension cordless telephone is cut after a prescribed period of time which is longer than that when an outgoing call is abandoned in mid-course or when the telephone is placed on the hook.

Operation up to the response to an incoming call to an outside line and the placing of an outside line on hold during a call will now be described in accordance with the sequence chart of Fig. 15.

When there is an incoming call from a public telephone line, the main controller 1107 transmits wireless-link establishment request information to the extension wireless controller 1105a (1501, 1502).

Upon receiving the wireless-link establishment request information (1501, 1502), the extension wireless controller 1105 transmits a wireless-link establishment

signal (1503) to the extension cordless telephone 1110a by a control channel.

At this time the call channel used between the extension wireless controller 1105a and the extension cordless telephone 1110a is communicated by the wireless-link establishment signal (1503) and the radio-wave receiving section is switched over to the call channel, thereby establishing a wireless link.

Meanwhile, since the control channel is already being used, the extension wireless controller 1105b waits for the control channel to become idle.

Upon receiving the wireless-link establishment signal (1503), the extension cordless telephone 1110a transmits a wireless-link establishment notification signal (1504) by the designated call channel.

Upon receiving the wireless-link establishment notification signal (1504), the extension wireless controller 1105a transmits a wireless-link establishment response signal (1505) to the extension cordless telephone 1110a and transmits wireless-link establishment confirmation information (1506) to the main controller 1107, thereby notifying of the fact that the wireless link has been established.

The extension wireless controller 1105 detects the idle control channel, transmits a wireless-link establishment request signal (1507) to the extension

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cordless telephone 1110b by the control channel,  
notifies of the call channel to be used subsequently and  
switches the radio-wave receiving section over to the  
call channel, thereby establishing a wireless link.

5        Upon receiving the wireless-link establishment  
confirmation information (1506) from the extension  
wireless controller 1105a, the main controller transmits  
outside-line incoming-call information (1508) to the  
extension wireless controller 1105a. Upon receiving  
10 this information, the extension wireless controller  
1105a transmits an outside-line incoming-call signal  
(1509), which includes an outside-line ringing tone and  
outside-line LED information, to the extension cordless  
telephone 1110a.

15        Upon receiving the outside-line incoming-call  
signal (1509), the extension cordless telephone 1110a  
produces an outside-line incoming-call tone by the  
ringing tone designated by the outside-line incoming-  
call signal (1509) and causes outside-line LEDs to light  
20 in the pattern designated by the signal (1509).

After the wireless-link establishment request  
signal (1507) has been sent and received, the extension  
wireless controller 1105b and extension cordless  
telephone 1110b perform operations (1510 ~ 1513) similar  
25 to those described above, cause the outside-line  
incoming-call tone to be produced by the extension

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cordless telephone 1110b and cause the outside-line LEDs to be lit.

Thereafter, when the extension cordless telephone 1110a is taken off the hook in order to answer the  
5 incoming call to the outside line, the extension cordless telephone 1110a transmits an off-hook signal (1514) to the extension wireless controller 1105a, which in turn transmits off-hook information (1515) to the main controller 1107.

10 Upon receiving the off-hook information (1515), the main controller 1107 causes the outside-line controller 1104 to acquire the outside line terminating the call, connects the switching section 1103 and makes possible an outside-line call by the extension cordless telephone  
15 1110a.

Since the incoming call to the outside line has been responded to with regard to the extension cordless telephone 1110b, it is necessary to halt the outside-line incoming-call tone and communicated new outside-  
20 line LED information. Accordingly, outside-line incoming-call abandonment information (1516) is transmitted to the extension wireless controller 1105 and the timer T2, which runs until the wireless link is cut off, is started.

25 Upon receiving the outside-line incoming-call abandonment information (1516), the extension wireless

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controller 1105b transmits an outside-line incoming-call abandonment signal (1517) to the extension cordless telephone 1110b. Upon receiving the signal (1517), the extension cordless telephone 1110b halts the outside-  
5 line incoming-call tone and causes the outside-line LEDs to light in the pattern designated by the outside-line incoming-call abandonment signal (1517).

Thereafter, when the timer T2 runs out of time, the main controller 1107, in order to cut off the wireless  
10 link, transmits wireless-link disconnect request information (1518) to the extension wireless controller 1105b. Upon receiving this information, the extension wireless controller 1105b transmits a disconnect request signal (1519) to the extension cordless telephone 1110b.

15 Upon verifying completion of reception of the disconnect request signal (1519) at the extension cordless telephone 1110b, the extension wireless controller 1105b, as well as the extension cordless telephone 1110b, halts the transmission of radio waves  
20 and cuts the wireless link.

When, during an outside-line call, a holding operation is performed at the extension cordless telephone 1110a in order to transfer or temporarily hold the call that is in progress, a hold signal is  
25 transmitted from the extension cordless telephone 1110a to the extension wireless controller 1105a. Upon

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receiving this signal, the extension wireless controller 1105a transmits holding information to the main controller 1107.

5       Upon receiving the holding information, the main controller 1107 sends a holding tone to the outside line and transmits outside-line holding information (1522, 1523) to the extension wireless controllers 1105a, 1105b.

10       Upon receiving the outside-line holding information (1522) from the main controller 1107, the extension wireless controller 1105a transmits an outside-line hold signal (1524) to the extension cordless telephone 1110a by the call channel since the wireless link has already been established.

15       Meanwhile, upon receiving the outside-line holding information (1523), the extension wireless controller 1105b transmits an outside-line hold signal (1525) to the extension cordless telephone 1110b by the control channel since a wireless link with the extension  
20       cordless telephone 1110b has not been established.

      Upon receiving the outside-line hold signals (1524, 1525), the extension cordless telephones 1110a, 1110b light the outside-line LEDs in the patterns designated by the outside-line hold signals (1524, 1525).

25       Further, the holding operation of Fig. 15 is performed after the wireless link between the extension

wireless controller 1105b and extension cordless telephone 1110b is cut. However, if the holding operation is performed before the wireless link is cut, the transmission of the outside-line hold signal (1525) to the extension cordless telephone 1110b is performed by the call channel.

Thus, it is possible to answer an incoming call to an outside line and place the call in progress on hold.

Described next will be the sequence chart of Fig. 16 showing operation when an outside-line button is pressed on the extension cordless telephone 1110b at such time that an outside line of the extension cordless telephone 1110a has been placed on hold, the sequence chart of Fig. 17 showing operation when a response is made to the holding outside line at the extension cordless telephone 1110b in a state in which the timer T2 is counting and a wireless link remains as established, and the flowchart of Fig. 18 illustrating these operations.

When the outside-line button on the extension cordless telephone 1110b is pressed in order to respond to the holding outside line (step S1801), the extension cordless telephone 1110b checks, using the wireless controller 1203, whether the wireless link has been established (step S1802). If the wireless link has been cut, the extension cordless telephone 1110b transmits a

wireless-link establishment request signal (1601) to the extension wireless controller 1105b by the control channel in order to establish the wireless link (step S1803).

5           Upon receiving the wireless-link establishment  
request signal (1601), the extension wireless controller  
1105b transmits an establish request signal (1602) to  
the extension cordless telephone 1110b by the control  
channel, designates the call channel to be used and  
10 switches the receiving section, which receives radio  
waves from the extension cordless telephone 1110b, over  
to the call channel, thereby establishing a wireless  
link.

Upon receiving the establish request signal (1602)  
15 at step S1804, the extension cordless telephone 1110b  
transmits a wireless-link establishment notification  
signal (1603) by the designated call channel (step  
S1805). Upon receiving this signal, the extension  
wireless controller 1105b transmits a wireless-link  
20 establishment response signal (1604) to the extension  
cordless telephone 1110b by the call channel and  
transmits wireless-link establishment notification  
information (1605) to the main controller 1107.

Upon verifying, owing to reception of the wireless-  
25 link establishment response signal (1604) from the  
extension wireless controller 1105b (step S1806), that

the wireless link has been established, the extension cordless telephone 1110b transmits an outside-line button signal (1606) to the extension wireless controller 1105b (step S1807). Upon receiving this  
5 signal, the extension wireless controller 1105b sends the main controller 1107 information (1607) indicating depression of the outside-line button.

Upon receiving the information (1607), the main controller 1107 changes over the switching section 1103  
10 and connects the call channel of the holding outside line from the extension wireless controller 1105a to the extension wireless controller 1105b, thereby making possible an outside-line call at the extension cordless telephone 1110b (step S1808).

15 If it is determined at step S1802 that the wireless link has been established, a signal (1701) indicating depression of the outside-line button is transmitted to the extension wireless controller 1105b (step 1807) owing to the fact that the wireless link has been  
20 established.

Upon receiving the signal (1701), the extension wireless controller 1105b sends the main controller 1107 information (1702) indicating depression of the outside-line button. Upon receiving this information, the main  
25 controller 1107 changes over the switching section 1103, connects the call channel of the holding outside line to

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the extension wireless controller 1105b and makes possible an outside-line call at the extension cordless telephone 1110b (step S1808).

More specifically, if the established wireless link  
5 remains in effect when a transfer is made to another telephone or a hold response is made at another telephone after the response to the incoming call from the telephone line is made, the sending/receiving of signals at S1803 ~ S1806 described in Fig. 18 and the  
10 sending/receiving of signals 1601 ~ 1604 and sending/receiving of information 1605 in Fig. 16 can be eliminated. The time required to hold and respond to an outside line and make a call possible can be shortened.

More specifically, as described in connection with  
15 Fig. 14, when the main unit detects an operation for responding to an incoming call, the time required to cut the wireless links between the main unit and extension cordless telephones other than that which performed the response operation is made longer than the time for  
20 cutting the wireless link by hanging up or by abandonment of the call on the originating side. As a result, the time needed for a hold response on the outside line can be shortened, as set forth above.

A fifth embodiment of the present invention will  
25 now be described.

In the fourth embodiment, it is so arranged that

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when an off-hook connection has been made on a wireless link, the set value of the disconnect timer of extension cordless telephones other than the extension cordless telephone that has answered is changed depending upon  
5 whether an outgoing call is abandoned by the originating side in mid-course or an operation is made to respond to an incoming call. In the fifth embodiment, it is so arranged that when an extension cordless telephone has performed an operation to respond to an incoming call,  
10 the wireless links to extension cordless telephones other than the extension cordless telephone that has responded are not cut.

Reference will be had to the flowchart of Fig. 19 to describe an operation in which, when the main unit  
15 1102 has detected an operation by the extension cordless telephone 1110a to respond to an incoming call, the wireless link of the extension cordless telephone 1110b, which is other than the extension cordless telephone that responded, is not disconnected during acquisition  
20 of a telephone line.

In Fig. 19, steps S1901 ~ S1903 are the same as steps S1401 ~ S1403, and steps S1908, S1909 are the same as steps S1408, S1409. These steps need not be described again.

25 The operating status of the disconnect timer is checked at step S1903. If the timer is not operating,

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monitoring is performed (step S1904) to determine whether the outside line responded to by the extension cordless telephone 1110b is continuing the call. If the call is continuing, the status, stored in the RAM 1109, that prevailed when the wireless link was established is checked (step S1905). In case of an off-hook connection, i.e., in case of disconnection owing to hanging up of the phone, the disconnect timer (e.g., 5 sec) is started (step S1906). In case of an incoming-call connection, whether the incoming call was suspended is checked (step S1907). If the call was abandoned from the originating side in mid-course, the program proceeds to step S1906, where the disconnect timer is started. The program then returns to step S1901.

15        If the call from the originating side is not abandoned at step S1907 and the other dedicated extension cordless key telephone 1110b responds to the incoming call, the program returns to step S1901 without starting the timer.

20        If the outside line responded to at step S1904 has been disconnected, a procedure for cutting the wireless link is started (step S1909) and the program makes a transition to step S1910 to wait for completion of the wireless-link disconnection.

25        Thus, when the main unit 1102 has detected an operation for responding to an incoming call, the



wireless links with all dedicated extension cordless  
telephones are not cut during acquisition of a telephone  
that has responded to an incoming call. When the  
telephone that has responded to an incoming call is  
5 disconnected, it is possible to cut the wireless links  
with all dedicated extension cordless telephones.

Fig. 20 is a diagram showing the construction of a  
system according to a sixth embodiment of the invention.

The system of Fig. 20 is additionally provided with  
10 an extension wireless controller 1105c and a wireless  
facsimile device 1111. The other components are the  
same as shown in Fig. 11 and need not be described  
again.

The wireless facsimile device 1111 performs  
15 facsimile communication via the PSTN 1101, and the  
extension wireless controller 1105c is for controlling  
the wireless facsimile device 1111. The type  
(telephone, facsimile, etc.) of extension device  
connected to each extension wireless controller is  
20 stored in the RAM 1109 in advance.

In a case where a wireless data communication  
device such as the facsimile device is included in the  
system, as shown in Fig. 20, the probability that a  
transfer from the extension cordless telephones 1110a,  
25 1110b will be made is low. Therefore, in this  
embodiment, the cutting of the wireless link of the

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wireless facsimile device 1111 is performed as in the fourth and fifth embodiments, namely at the time of off-hook connection or when an outgoing call is abandoned on the originating side.

5        Fig. 21 is a flowchart illustrating the operation of the main unit in this embodiment. Operation in accordance with this flowchart will now be described.

10        When a wireless link has been established between the extension wireless controller 1105 and the extension cordless telephones 1110 and wireless facsimile device 1111, the main controller 1107 monitors the hook status of the extension cordless telephones 1110a, 1110b and wireless facsimile device 1111 (step S2101). If any one of the extension cordless telephones 1110a, 1110b or 15 wireless facsimile device 1111 is off the hook, the program returns to step S2101. If any one of these is on the hook, the main controller 1107 monitors the incoming-call status of the outside line (step S2102). If the incoming call is continuing, the program returns 20 to step 2101. If there is no incoming call, the main controller 1107 checks a disconnect timer (step 2103). If the timer is not operating, the main controller 1107 checks the status, stored in the RAM 1109, that prevailed when the wireless link was established (step 25 S2104). In case of an off-hook connection, the main controller 1107 starts the timer T1 (step S2105). In

case of an incoming-call connection, the main controller 1107 checks whether the incoming call was suspended (step S2106).

If the call was abandoned from the originating side  
5 in mid-course, the program proceeds to step S2105, where the disconnect timer T1 is started.

If the call from the originating side is not abandoned at step S2106, an incoming-call response is made at step S2107 after judging whether the wireless  
10 terminal is an extension cordless telephone or the wireless facsimile machine. If the wireless terminal is the facsimile device 1111, the timer T1 is started in order to cut the wireless link with the other wireless terminals (the extension cordless telephones 1110a,  
15 1110b).

If the extension cordless telephone has responded to the incoming call at step S2107, then the program proceeds to step S2108.

It is determined at step S2108 whether the wireless  
20 link to be cut is that of the extension cordless telephones or of the wireless facsimile device. In case of the wireless facsimile device, the program proceeds to step S2105. If the wireless link cut is that of the extension cordless telephones, the disconnect timer T2,  
25 which has been set to a time longer than that of the disconnect timer T1, is started at step S2109. and the

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program returns to step S1401.

If the disconnect timer has already been started at step S2103, the timer performs a counting operation (step S2110) and the program returns to step S2101 if  
5 the timer has not run out of time. If the timer has run out of time, the timer is halted and a procedure for cutting the wireless link is started (step S2111), after which the program makes a transition to step S2112 to wait for completion of the wireless-link disconnection.

10 Thus, in a case where the system incorporates devices having various functions, the time up to cutting of the wireless link can be changed depending upon the communication function of the device.

In the fourth through sixth embodiments, the set  
15 time of the disconnect timer T2 is longer than that of the disconnect timer T1. This set time is a fixed time period. However, in a seventh embodiment, it is so arranged that the set time of the disconnect timer T2 can be changed by the operation in dependence upon  
20 application in which the system is put to use.

Fig. 22 is a diagram showing the construction of the main unit 1102 according to the seventh embodiment.

In Fig. 22, numeral 1112 denotes a control panel, which is provided with a switch of the kind shown in  
25 Fig. 23. This makes it possible to freely change the set time of the disconnect timer T2. Other components

in Fig. 22 are the same as those in Fig. 20 and need not be described again.

In Fig. 23, numeral 2301 denotes a control panel having a display 2302 which displays the set time of the disconnect timer T2. By moving a variable switch 2303, the time of the disconnect timer T2 can be set with facility.

A control panel of this kind can be provided in the apparatus of the first through third embodiments, thereby making it possible to change the set values of the timers 250, 340.

In the first through seventh embodiments, the example of the wireless link described relies upon radio waves from a low-power system. However, it is obvious that the present invention can be implemented in a similar manner also in various wireless telephone systems in which wireless communication relies upon very low-power radio waves or other radio waves, light such as infrared rays, etc. There is no particular limitation upon the type of wireless link.

The arrangement of the cordless key telephone apparatus shown in Fig. 11 is only one example and it goes without saying that there are many other arrangements available. The invention is not limited to a key telephone apparatus. It is obvious that the invention is applicable in similar fashion to a cordless

telephone system in a public branch exchange or business office.

With regard to the type of outside line, the invention is not limited to an ordinary public telephone  
5 line. The line may be an extension in a public branch exchange (PBX), a digital line typified by an ISDN, a special-purpose line or a line in a private network.

There is no limitation upon the type of extension terminal accommodated. If a plurality of dedicated  
10 cordless telephones are accommodated, dedicated telephones, ordinary subscriber telephones (SLTs), facsimile machines or other telephone terminals conventionally connected to the main unit by lines may be accommodated.

15 The extension wireless controllers are accommodated within the main unit. However, they may be provided outside the main unit and connected thereto by line wires.

In the foregoing embodiments, the timers in the  
20 main controller are described as being software. However, hardware timers may be employed.

In accordance with the embodiments of the invention described above, in an instance where a calling party receives a response from a party different from the  
25 intended party after the incoming call from a public telephone line is terminated and answered, as is often

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the case where a hold-and-transfer operation is used most frequently, the time needed for cutting of the wireless link after the response to an incoming call is made is lengthened. As a result, the operation for  
5 effecting transfer to another telephone or for holding and answering at another telephone can be facilitated and the waiting time of the calling party is shortened.

In a case where various devices, such as a facsimile device, which communicate data other than  
10 voice data are included in the system, the cutting of the wireless link can be performed in dependence upon the function of the device.

Further, by providing a switch for setting time up to the cutting of the wireless link, the operator is  
15 capable of setting the time in dependence upon the application or conditions of use. Accordingly, in a wireless communication system which accommodates devices having a plurality of functions, the time up to the cutting of the wireless link of each device can be  
20 changed in conformity with the function of the device and the state of use of the system.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the  
25 invention is not limited to the specific embodiments thereof except as defined in the appended claims.